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Analytical theory of the coherent generation in the resonant-tunneling diode

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The experiments on the observation of generation in the resonant-tunneling diode (RTD) in the region of ultra-high frequencies (up to 712 GHz, E. R. Brown *et al.* 1991) has demonstrated the perspectives for using of such structures as sources of generation. However, the observed output power of these generators was too small. The physical nature of such small values of the output power as well as the ways and perspectives to increase it remain still unclear despite a considerable number of theoretical works. Unfortunately, majority of these works employ numerical approach giving no way for their analysis. Developed analytical theories are phenomenological in essence. At the same time, the coherent system requires the rigorous quantum-mechanical description.

The consequent quantum-mechanical theory of the coherent generation in the RTD is developed in the present work. Exact analytical solution of the set of equations describing the generation is obtained for the case of weak electromagnetic field. The expressions for the active and reactive components of the polarization currents are derived. It is shown that these expressions are essentially different from those obtained in earlier published works employing semi-phenomenological approaches. The analysis of results enabled one to elucidate the mechanism of generation in the RTD and to show that it is principal different from the generation mechanism in lasers. Moreover, the values of threshold pumping currents and generation frequencies were calculated. The dependence of these quantities on the structure parameters was determined also. The developed model gives one a possibility to estimate the optimal parameters of the structure as well as the perspectives of RTD-based generators.